Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic ISSN 1842-4309

Not. Bot. Hort. Agrobot. Cluj 37 (1) 2009, 157-164

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

# The Evaluation of Using Resistograph when Specifying the Health Condition of a Monumental Tree

Marcin KUBUS [1]

[1] *Department of Dendrology and Landscape Architecture, West Pomeranian University of Technology, Janosika 8 Street, 71-424 Szczecin, Poland; mkubus@zut.edu.szczecin.pl*

**Abstract**

The health condition as well as the mechanical status of Large-leaved Lime were determined by the visual and invasive methods using IML 400 Resistograph. Ten measurements of the two co - dominant boughs were made in order to specify their internal condition. Despite only minor deadwood in its crown, "Dobrosława's" health condition is poor and related to its extensive internal cavities. All the measurements taken using resistograph enabled the full diagnosis of the tree's health condition. On the basis of the findings, the decision concerning the way and the range of required care treatments was made.

***Keywords:*** resistograph, health condition, monumental trees, Large-leaved Lime "Dobrosława"

## Introduction

The inspection of the health condition of old trees, especially of those growing in the cities, in the villages or adjacent to footpaths and roads - potentially causing a great risk to people and their property - is required from time to time. What is more, it is necessary to specify the tree's mechanical status which is determined by the construction of the tree crown (its position, geometry, size, arrangement of boughs and further branching) as well as the size of trunk cross-section or boughs being at risk of load, mechanical and physical wood properties, load (self weight and external loads i.e. wind, rain, snow)-Siewniak (2003), Wessolly (2003).

Assessment of the health condition of a tree is not always possible without the diagnosis of internal state of its trunk and boughs (Gross, 2002; Siewniak and Kusche, 1994; Wessolly and Erb, 1998). It is especially necessary when analysing the condition of particular tree species. For example, the internal damages – decreasing mechanical and physical parameters of a tree-without external symptoms of poor health condition are common in poplars and limes (Seneta and Dolatowski, 2000; Kasprzak, 2005).

The aim of this work was to evaluate the possibility of using IML 400 Resistograph to specify the health condition and mechanical status of monumental trees on the example of Large-leaved Lime (*Tilia platyphyllos* Scop.) "Dobrosława" – one of the most imposing trees of this species that grow in Poland.

## Materials and Methods

The material under research was Large-leaved Lime "Dobrosława" that grows in Jaglice (north - west Poland), in Zielony Stok forestry in West Pomerania Province (fig. 1, Photo. 1). In 2006 the thorough assessment of the health condition and mechanical status of this tree was described by the visual and invasive methods using IML 400 Resistograph, enabling the study of the tree's inner structure.

### *The characteristics of the inspected tree*

"Dobrosława" has got impressive dimensions: height – 26 metres, tree crown diameter - 21 metres, trunk circumference at the height of 130 cm - 816 cm. At the height of 3 metres, the trunk is divided into two huge (growing from the same point) boughs having 555 and 468 cm in their circumferences (Photo. 1). The tree has also formed (from the shoots of the roots) two stems having 268 and 168 cm in their circumferences (the circumference's outline concerning all trunks is 1066 cm). In 1954 the tree was registered as the nature monument and in 2002 was pronounced, in the competition conducted by "Przegląd leśniczy" magazine, the thickest tree regarding its species that grows in the area of the state forests in Poland. "Dobrosława's" age has

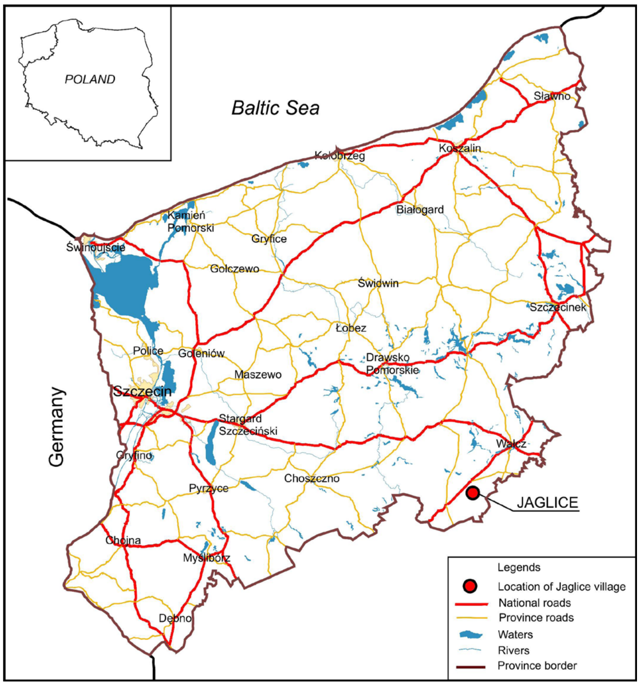


Fig. 1. The location of Jaglice village

Photo. 1. "Dobrosława's" huge trunk and boughs (phot. M. Kubus)

been estimated between 350 and 390 years. The trunk and boughs have extensive cavities. The boughs broke off in different periods of time, i.e. in 2003 as a result of progressing internal wood degradation, the huge lateral bough broke off. The cavities were filled with sand and rubble, and their outlets were either concreted or walled up as those procedures used to be regarded as care treatments. The largest of all the cavities, is the the cavity occurring on the perpendicular parts of a trunk (vertical pipe cavity). Its outlet is right below its fork. It is entirely filled with gravel, sand and rotting wood, and its outlet was covered with "concrete and rubble cap" (currently cracked in some parts) -Photo. 1. At different heights the boughs are divided into regular branching so that they form another rows. Despite extensive cavities in the trunks and boughs, the tree is visually – considering its foliage-in good health condition. In the tree crown, deadwood branch is visible covering about 5-7% of crown's size. Also bough deadwood is noticed in the form of one withered lateral bough.

### *The operation and the method of analysis of "Dobrosława's" internal health condition using IML 400 resistograph*

The instrument measures the resistance to a needle inserted into the wood under constant drive. It consists of a drilling unit and electronic unit that are connected with power supply cables in order to transfer the data. The drilling unit has a steel, elastic coming out borer that has 3 mm in diameter and length of 40 cm. As the micro drill enters the tree, it meets the internal resistance of different parts of the wood. The resistance of the wood changes the rotation speed of the drill causing changes in the absorption of electric power (Göerlacher R. and Hättrich R. 1990, Rinn 1994). This information is transferred to electronic unit by the cable responsible for translating the data. Later on, it is registered on electronic unit's memory and printed as a graph (mosaic printer is the integral part of this instrument)-Photo. 2. At the same time, the current data concerning the depth of a borer in the wood (shown on a borer-depth pointer) and the absorption of electric power (shown on a resistance gauge) are displayed - the greatest electricity resistance, the greatest absorption of electric power. What is more, the resistograph is equipped with a crank to control sensitivity in three spans, so that it enables printing the graph at a scale of 1:1, 2:1, 3:1 (enlargement enables data's correct reading and interpretation). Depending on the hardness of the analysed wood, the velocity of the borer's shift is adjusted by the crank in the range of six ratios - 10, 15, 20, 30, 40, 45 cm/min (the greatest wood's hardness, the slowest borer's shift). After switching on, the resistograph automatically prints keyed in data (contractor's name, project's title) as well as current settings (measurement number, shift velocity, amplitude, date, the exact time of the measurement and current batteries voltage). The data collected by the recorder can be sent to any computer and analysed in the Resistograph Software F-Tools programme (Rinn, 1994; Kubus and Połomski, 2006), was done in this research.

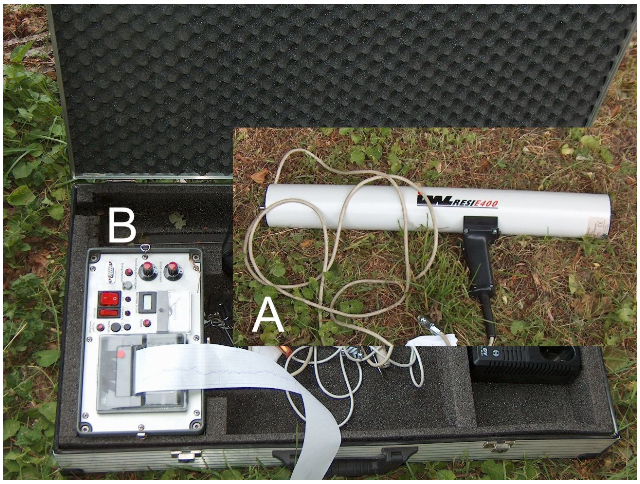


Photo. 2. IML 400 Resistograph: A-drilling unit, B-electronic unit integrated with mosaic printer (phot. M. Kubus)

According to Nicolotii *et al.,* (2003) the research carried out with the use of a resistograph allow to obtain data only from the place of the tree that was bored. Therefore, in order to obtain representative information about the inside of a trunk or a bough it is necessary to carry out a greater number of bore-holes, e.g. two situated perpendicularly towards each other.

The studies with the use of resistograph allow to analyse the tree's annual growth of rings what has its application in the dendrogeomorphological monitoring (Lopez Saez i in. 2008). According to Isik and Li (2003) it is reliable device for assessing relative wood density of live trees especially that the method is rapid and nondestructive.

Photo. 3. The occurrence of one of the drillings on a stemabove the cavity (phot. M. Kubus)

**Results and Discussions**

"Dobrosława" was measured ten times. Four measurements of the trunk number 1, circumference of 468 cm (at the height of 4,5 metres above the ground) and six measurements of the trunk number 2 were taken, circumference of 555 cm (at the height of 7 metres above the ground). The drillings were made according to the four quarters of the globe and in the places important for the bough's mechanical status (Photo. 3), taking into consideration Nicolottie's and al. (2003) earlier guidelines. Fig.s 2 and 3 depict the graphs printed from the resistograph, which were later interpreted in Tab. 1.

The findings concerning "Dobrosława's" internal stucture have shown that the trunk and boughs' internal cavities are extensive. The tree's interior is filled with a cavity that has approximately the capacity of 15 m3 (measured from the base of the trunk up to its fork at the height of 3 m). The thickness of the static hardwood layer of the boughs (being at risk of load), fluctuates between approximately 9 cm to 35 cm (Fig. 2 and 3). The thickest layers of the hardwood concerning two boughs are from the side of their fork, north - south axis, and they mostly maintain the mechanical status of the main boughs. In the boughs' internal structure, where the drillings occurred, there are hardwood layers which undergo different rates of stress connected with boughs' mechanical status maintenance (bough number 1-measurement number 1, 2; bough number 2-measurement number 5, 8, 9, 10). Bough number 2 undergoes particularly great stress

On the basis of the findings obtained via visual method and the study of the tree's internal structure with the usage of resistograph, the decision concerning carrying out the following care treatments according to suggestions applied to tree maintenance was taken (Chachulski 2000, Gross 2002, Skup 1995).

Guidelines of treatments concerning trunk and boughs

1. The cavity occurring on the perpendicular parts of a trunk (vertical pipe cavity) should be cleaned out from rotting wood, rubble, concrete. Sand and gravel should be also removed. As the cavity's tip reaches subsoil, it ought to be uncovered below the level of the ground at the depth of 15-20 cm. Its whole area should be cleaned out up to the layer of hardwood and then impregnated (i.e. Imprex W). The hole being below the level of the ground should be filled with thick, rinsed gravel or with chippings (size fraction 5-25 cm). The hollows that are in the main boughs' fork need cleaning out from rotting wood and impregnation.

2. The removal of concrete and brick seals covering the outlets of so called open cavities. With regard to mechanical status, they are unnecessary or even disadvantageous as they additionally load the boughs. Moreover, they unable the air circulation in the cavities as well as ventilation and drainage.

3. The cavities clean - up to the hardwood layer (not up to free of disease layer, in such a way in order to avoid de-

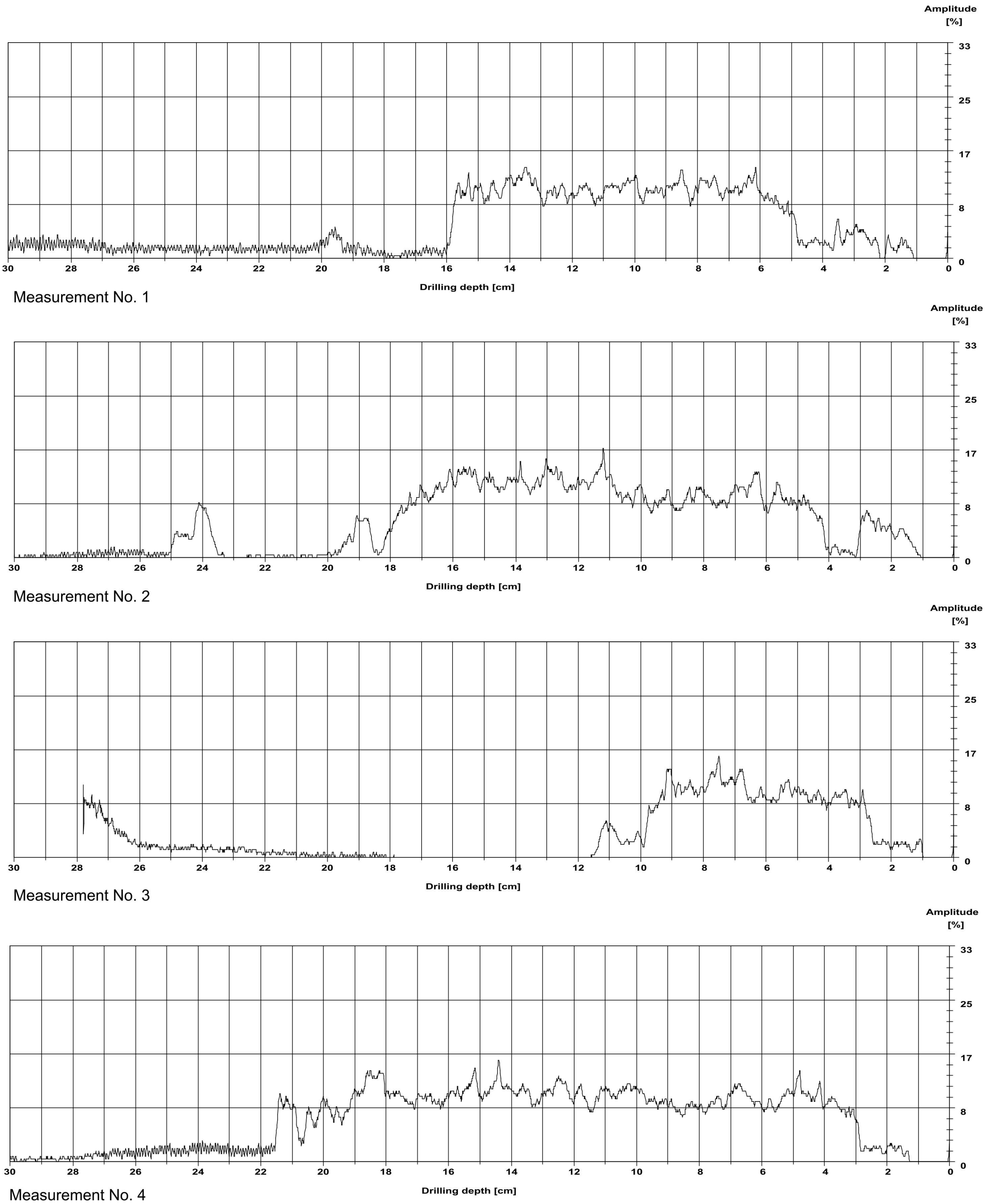


Fig. 2. The measurements of bough number 1

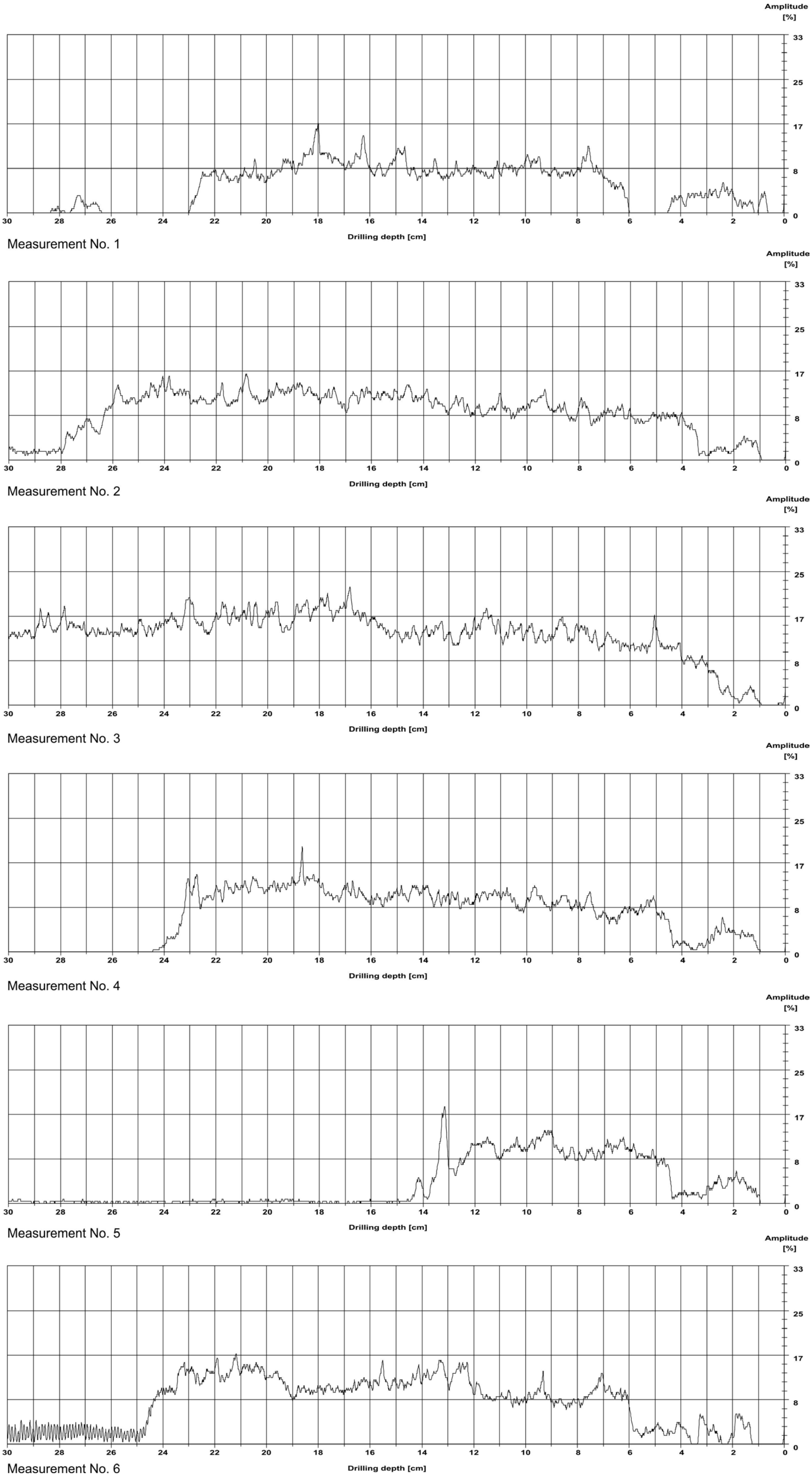


Fig. 3. The measurements of bough number 2

Tab. 1. The interpretation of the findings of "Dobrosława's" health condition

| No. | Measurement: No. / height [m] above the ground level drilling direction | Drilling depth [cm] | Graph translation, needle reach, notes |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| | | Bough No. 1 | |
| 1. | 1 / 4.5 / over the cavity E - W | 0-1 | needle access |
| | | 1-4.5 | cork |
| | | 4.5-5.0 | cambium |
| | | 5.0-15.5 | hardwood |
| | | 15.5-32 | degraded wood, rotting wood |
| | | 32-35 | partly degraded wood with greater hardness |
| | | 35-40 | lack of data |
| 2. | 2 / 4.5 / S - N | 0-1 | needle access |
| | | 1-4.5 | cork |
| | | 4.5-5.0 | cambium |
| | | 5.0-17.5 | hardwood with different stress (max at the depth of 11cm) and hardness |
| | | 17.5-40 | completely degraded wood, humus cavity having small parts of wood being harder than in other parts |
| 3. | 3 / 4.5 / W - E | 0-1 | needle access |
| | | 1.0-2.5 | cork |
| | | 2.5-3.0 | cambium |
| | | 3.0-9.5 | hardwood with different stress and hardness |
| | | 9.5-11.5 | wood with lesser hardness, initial wood decay |
| | | 11.5-26.5 | completely degraded wood, humus cavity |
| | | 26.5-28.0 | wood with minor hardness |
| | | 28.0-40.0 | lack of data |
| 4. | 4 / 4.5 / N - S | 0-1.0 | needle access |
| | | 1.0-3.0 | cork |
| | | 3.0-3.5 | cambium |
| | | 3.5-19.0 | hardwood with different stress and hardness |
| | | 19.0-21.5 | wood with minor hardness, initial wood decay |
| | | 21.5-36 | completely degraded wood, humus cavity |
| | | 36.0-40.0 | wood with minor hardness |
| | | Bough No. 2 | |
| 5. | 1 / 7 / E - W | 0-0.5 | needle access |
| | | 0.5-4.5 | cork |
| | | 4.5-6.0 | empty surface |
| | | 6.0-6.5 | cambium |
| | | 6.5-22.5 | hardwood with different stress and hardness |
| | | 22.5-40 | completely degraded wood, humus cavity |
| 6. | 2 / 7 / over the cavity S - N | 0-1.0 | needle access |
| | | 1.0-3.5 | cork |
| | | 3.5-4.0 | cambium |
| | | 4.0-26.0 | hardwood |
| | | 26.0-28.0 | wood with lesser hardness, initial wood decay |
| | | 28.0-40.0 | completely degraded wood, humus cavity |

Tab. 1. The interpretation of the findings of "Dobrosława's" health condition (Continuos)

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| 7. | 3 / 7 / over the cavity W - E | 0-1.0 | needle access |
| | | 1.0-3.0 | cork |
| | | 3.0-3.5 | cambium |
| | | 3.5-36.5 | hardwood with different stress and hardness |
| | | 36.5-40.0 | wood with minor hardness, the possibility of initial wood decay |
| 8. | 4 / 7 / N - S | 0-1.0 | needle access |
| | | 1.0-4.5 | cork |
| | | 4.5-5.0 | cambium |
| | | 5.0-23.0 | hardwood with different stress |
| | | 23.0-24.0 | wood with lesser hardness, initial wood decay |
| | | 24.0-40.0 | completely degraded wood, humus cavity |
| 9. | 5 / 7 / N-W - S-E | 0-1 | needle access |
| | | 1-4.5 | cork |
| | | 4.5-5.0 | cambium |
| | | 5.0-12.0 | hardwood |
| | | 12-14.5 | wood with lesser hardness, with great stress and degraded wood |
| | | 14.5-32 | completely degraded wood, humus cavity |
| | | 32-35 | foreign body - metal |
| | | 35-40 | lack of data |
| 10. | 6 / 7 / N-E - S-E | 0-1.5 | needle access |
| | | 1.5-5.5 | cork |
| | | 5.5-6.0 | cambium |
| | | 6.0-23.5 | hardwood with different stress and hardness |
| | | 23.5-24.5 | wood with lesser hardness, initial wood decay |
| | | 24.5-40.0 | completely degraded wood, humus cavity |

structing tree's phenol barrier). Where possible, impregnate using fungicide preparations (i.e. Imprex W).

Guidelines of treatments concerning crown

1. Reduction cuts (crown reduction) based on the reduction of the tree's height of one - fourth or maximum one - third maintaining the shape of tree's crown. The aim of such a cut is to minimize tree's centre of gravity and at the same time, to enhance its mechanical status. After the cuts of living branches, the wounds should be preserved by the surface fungicidal preparations, for example Lac-Balsam, Dendromal 03 PA, Funaben 3.

2. Tending cuts - the removal of dry, ill, cracked branches from the crown;

3. The installment of so - called "cobra" cable bracings in Ring System or Triangular System. The bracings on a bough should be installed not higher than at the two - thirds of a tree's height (between the crotch and the tip). The special accuracy is necessary when installing the bracings on a regrowth stem leaning towards road direction. When the bracing bough has a cavity, so - called double belts bracing is required.

**Conclusions**

Despite only minor deadwood in its crown, "Dobrosława's" health condition is poor and related to its extensive cavities.

All the measurements taken using resistograph enabled the full diagnosis of the tree's health condition. On the basis of the findings, the decision concerning the way and broad of required care treatments was made, i.e. reduction cuts in the crown, uncovering and preservation of trunk and boughs' cavities, places and systems applied to so called "cobra" cable bracing. Data was also used in the cost calculation concerning care treatments.

As the resistograph operation is quite easy, data and graph interpretation requires a great deal of experience. The tree inspection with the usage of resistograph is the least harmful invasive method ( that should be applied in the minimal extent required to receive the reliable outcomes. It is very important, therefore, to set a precise plan of bore-holes in a tree.

## References

Chachulski, Z. (2000). Chirurgia drzew. Legraf, Warszawa.

Gross, W. (2002). European treeworker. European Arboricultural Council (EAC). Pater Verlag. Berlin-Hannover.

Göerlacher, R. and R. Hättrich (1990). Die Bohrwiderstandsmessung. Bauen mit Holz. 6:455-459.

Isik, F. and B. L. Li (2003). Rapid assessment of wood density of live trees using the IML-Resistograph for selection in tree improvement programs. Canadian Journal of Forest Research. 33:2426-2435.

Kasprzak, K. (2005). Ochrona pomników przyrody. Zasady postępowania administracyjnego. Wydanie V. Wydaw. Abrys, Poznań.

Kubus, M. and J. Polomski (2006). Rezystograf - urządzenie które warto mieć. Drzewa, krzewy, park. PTCHD NOT, nr 13, rok IX, Łódź:26-27.

Lopez Saez J., C. Corona and F. Berger (2008). Use of resistograph for dendrogeomorphological analysis of avalanche impacts (Massie de l'Oisans, France). Geophysical Research Abstracts Vol. 10, EGU General Assembly.

Nicolotti, G., L. V. Socco., R. A. Martinis Godio and L. Sambuelli (2003). Application and Comparison of Three Tomographic Techniques for Detection of Decay in Trees. J. Arboric. 29(2):66-78.

Rinn, F. (1994). Jahrringe im Bohrwiderstandsprofil. Bautenschutz Und Bausanierung. 7:17-24.

Seneta, W. and J. Dolatowski (2000). Dendrologia. Wydaw. Nauk. PWN. Warszawa.

Siewniak, M. and D. Kusche (1994). Baumpflege heute. Berlin-Hanover.

Siewniak, M. (2003). Ocena stanu zdrowotności drzew miejskich na podstawie symptomów morfologicznych. Mat. Konf. Zieleń w przestrzeni miejskiej jakość i radość życia. Warszawa.

Skup, A. (1995). Pielęgnacja i ochrona drzew (z normami jakości). KWANT Zacher.

Wessolly, L. (2003). Ocena stanu zachowania i przewidywanie przeżywalności drzew na podstawie statyki i konstrukcji drzew. Mat. Konf. Zieleń w przestrzeni miejskiej jakość i radość życia. Warszawa.

Wessolly, L. and M. Erb (1998). Handbuch der Baumstatik und der Baumkorolle, Berlin, Hanower. Karta inwentaryzacyjna drzewa z zasobów Biura Konserwacji Przyrody w Szczecinie. Przegląd leśniczy nr 3/2002. Rozstrzygnięcie konkursu na najgrubsze drzewo Lasów Państwowych u progu XXI w., 4-29.