

ROLE OF ROOT MORPHOLOGY IN TREE ANCHORAGE: NUMERICAL ANALYSIS COUPLED WITH 3D LASER SCANNING AND 3D PRINTING

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Aims

a) To generate a 3D morphology of a European beech root system using laser scanning

b) To provide statistics for morphological properties of roots

c) To carry out numerical analysis of directional loading in relation to root distribution in space

d) To validate the numerical model by utilizing 3D printing

Materials and methods

A root system of a European beech tree was excavated at the university enterprise Masaryk Forest Křtiny. The tree measured 13 cm dbh and 15,5 m in height.



Fig. 1: Root system during excavation using AirSpade technology. White line marks removed soil level, orange dot marks North.

The root system was mounted (Fig. 2) and scanned using a 3D laser scanning metrology system (HandySCAN 307, Creaform Inc., Canada).



Fig. 2: Mounted root system prepared for scanning.

Associated software (VXelements, Creaform Inc., Canada) was used for surface reconstruction and digital measurements of the root system.

The 3D root system model and its response to lateral load will be evaluated using static structural analysis in Ansys simulation software package. Validation of the FE model will be done on a 3D print based on the generated 3D root system model.

Results

Preliminary results show no significant difference between hand and digital measurements of the postprocessed root system (paired t-test, $p = 0,673$). Total volume is 0,021 m³. Overall 82 branches were measured. Total length of all the branches is 236,23 m. Mean diameter is 1,7 cm, with a min of 0,7 cm and max of 5,4 cm.

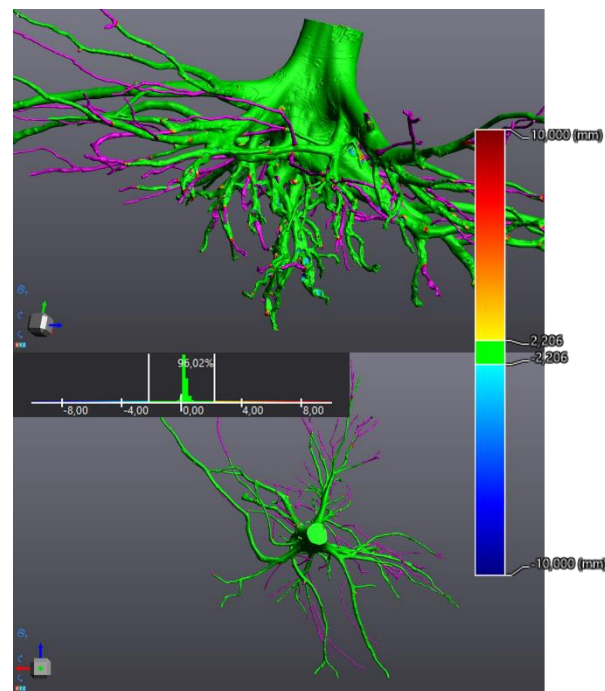


Fig. 3: Comparison of two 3D models of the root system – non processed model with the processed model used for the FE analysis. Differences are reported in change in distance between two surfaces of the models in millimeters, allowed tolerance (green color) set to 2,2 mm.

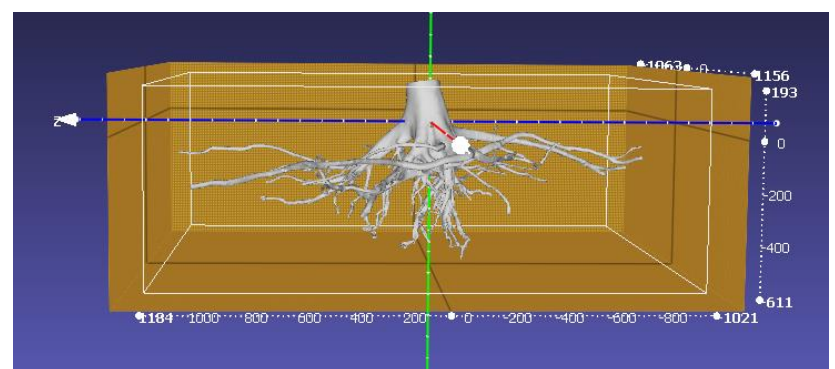


Fig. 4: Mesh bounding box in mm (snapshot origin MeshLab). Z axis marks EW direction. Zero at Y axis (vertical) defined at soil level, i.e. depth of large structural roots reaches 61,1 cm soil depth.

Conclusions

The spatial distribution of roots within a tree root system significantly influences the global mechanical response of the tree root system under load.

Laser scanning and 3D modeling, coupled with FE analysis poses a great alternative to current destructive and semi destructive methods for tree root system evaluation.

References

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