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LIFE HAZARD DURING A DIRECT LIGHTNING STRIKE TO LPS OF PUBLIC BUILDINGS

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Abstract - The purpose of this paper is to provide knowledge about the distributions of step and touch voltage around building with lightning protective system during direct lightning stroke to this system. These distributions were computed based on field theory approach.

1 INTRODUCTION

Lightning stroke to lightning protective system LPS of building can cause damage to electric and electronic equipment and can be dangerous for the people inside and outside this building. Transient step and touch voltages can arise on the ground surface due to surge current injected into the soil by the earth electrode.

Still, not much information concerning the life hazard caused by transient electric stress on human being is providing.

Taking this fact into account, paper presents the results of numerical simulations of touch and step voltages distributions around the buildings in the case of direct lightning stroke to LPS. The mathematical model includes the wires of LPS, earthing network as well as simplified model of human body [1].

2 NUMERICAL SIMULATIONS

During analysis two types of public buildings: shopping centre and civil office (Fig.1.) were considered.

In the areas adjacent to these structures a large number of people frequently assemble and potential control for such areas was provided by the additional ring earth electrodes.

2.1. Civil office

The calculations were made for the simple external LPS, which protect the civil office with the following dimensions 40m x 15m and height 28m (Fig.1). The basic parts of the LPS was "meshed" air-termination system with the mesh size 9,5 m x 12,5 m.

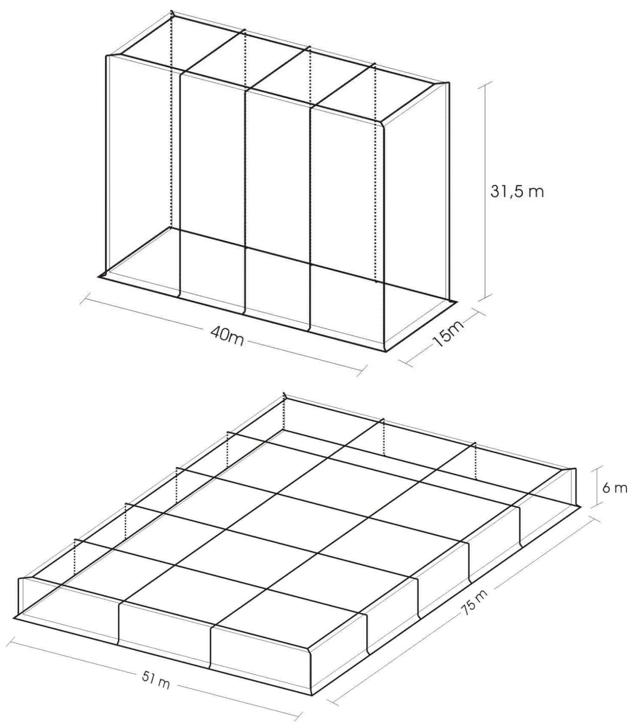


Fig. 1 - Geometrical configuration of shopping centre and civil office

Ten down conductors conducted the intercepted lightning current to the ring earth electrode 1 m from the structure completely embedded into the soil at 0,5 m depth (Fig.2.).

A direct lightning stroke is simulated by an ideal current source presented by the following equation:

$$i(t) = \frac{I}{\eta}\left(e^{-\alpha t} - e^{-\beta t}\right)$$

where: *t - time*, α= *2049,38* s^{-}, β=*563 768,3* s^{-1}, *I=100kA*, η=*0,976.*

According to the standard IEC 61312-1 [3], such a waveform is characterized by the peak value 100 kA, front time 10 µs and time to half value 350 µs.

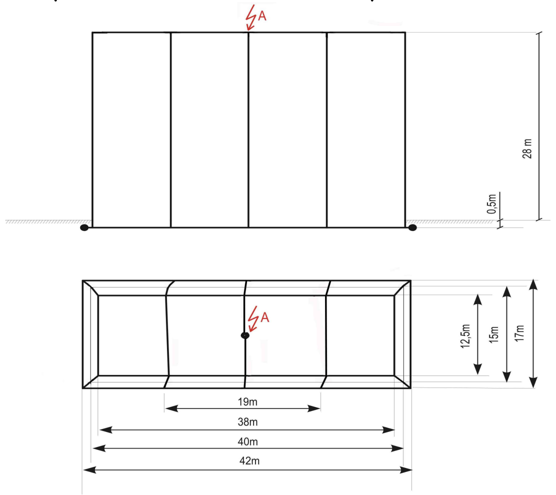


Fig. 2 - Geometrical configuration of LPS

In investigations this surge current, which simulated the first lightning stroke in the channel, this was injected to the different points of LPS.

Numerical simulations were performed by MultiFields [2] software package, which is a part of CDEGS package. The computation methodology assumes frequency decomposition of the time domain current surge, frequency domain computations for a single harmonic unit current and superposition of the frequency domain computations modulated by the amplitude of the lightning current. The calculation allows an evaluation of the crest values of step and touch voltages and the graphical distribution of it during lightning stroke to LPS. Some examples of results for direct stroke in the middle of LPS with one ring electrode were presented in Fig. 3 and 4.

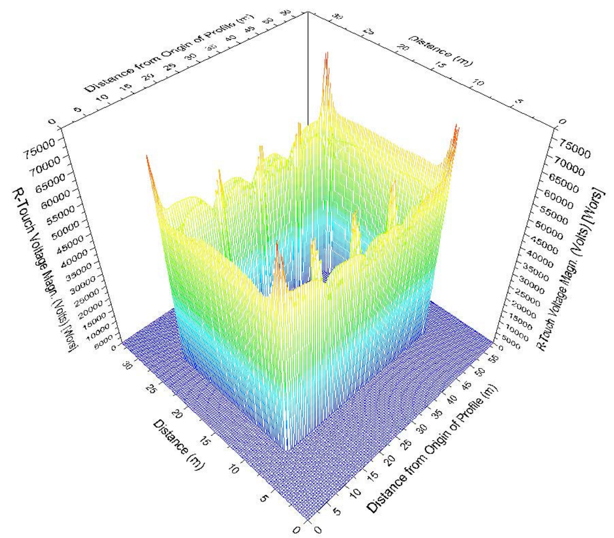


Fig.3 - Touch voltage distribution (maximal values) for one ring earth electrode*)*

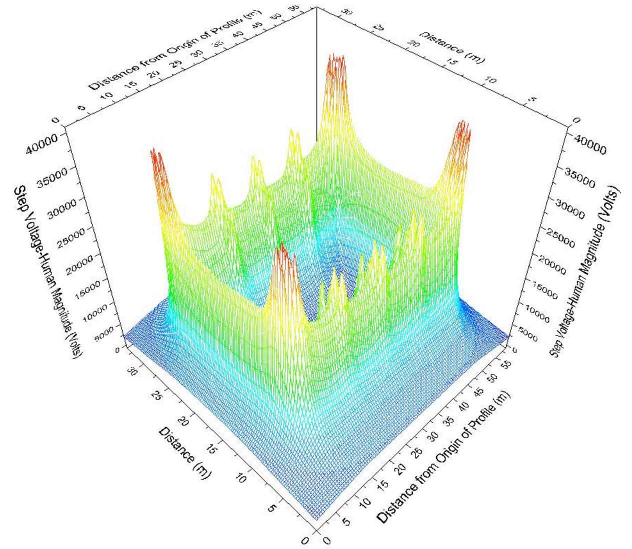


Fig.4. Step voltage distribution (maximal values) for one ring earth electrode

Where large numbers of people frequently assemble in the areas near the structures further additional ring earth electrodes should provide potential control.

These electrodes were installed 4 m, 7 m and 10 m from the structure at depths 1,5m, 2,5m and 3,5m adequately. The down conductors were connected to all rings of the potential control system. General geometric configuration of LPS and earthing system is shown in Fig. 5.

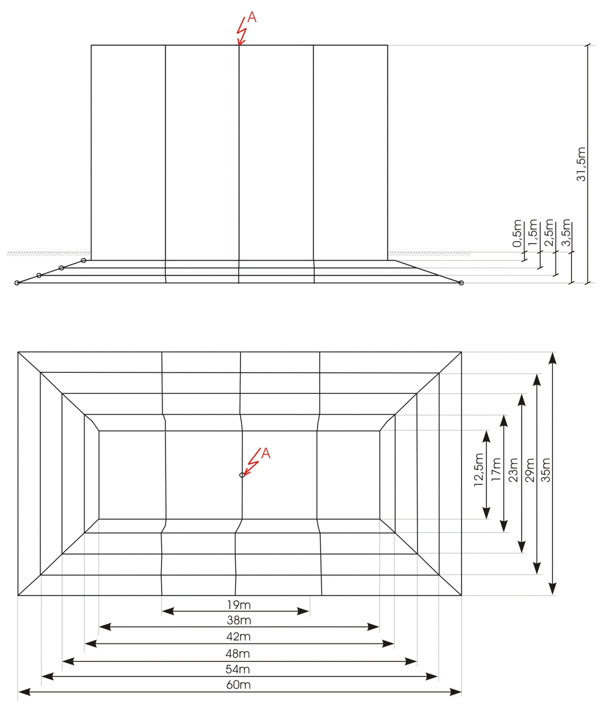
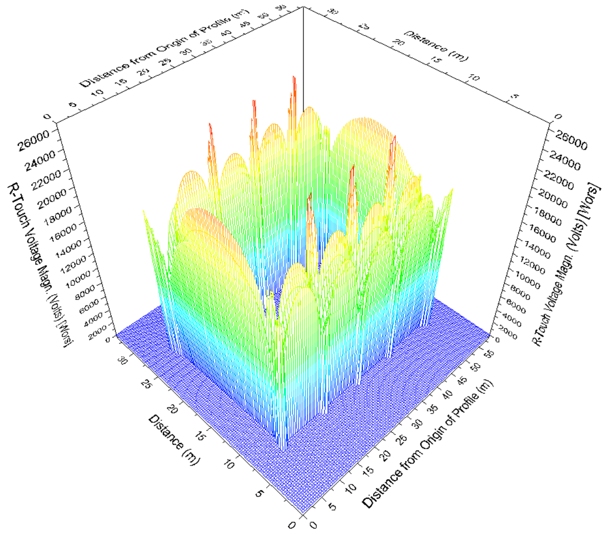


Fig. 5 - Geometrical configuration of LPS

Fig. 6 and 7 show he distributions of step and touch voltages around the building with additional ring earth electrodes during lightning stroke to LPS.

LPS with 2 ring earth electrodes



LPS with 4 ring earth electrodes

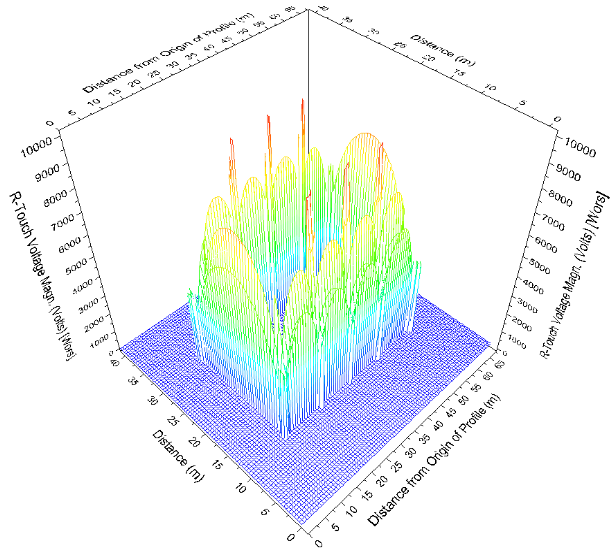


Fig. 6 - Touch voltage distributions near building
LPS with 2 ring earth electrodes

The maximal values of touch and step voltages for these LPS with different grounding system are presented in Tab. 1.

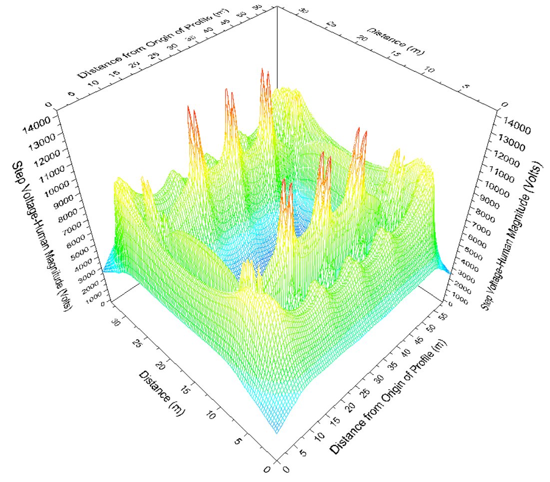
Table 1. The maximal values of touch and step voltages

Grounding system	Max. touch voltage	Max. step voltage
1 ring	76982	39665
2 rings	26461	13982
3 rings	14918	6932
4 rings	9827	4555

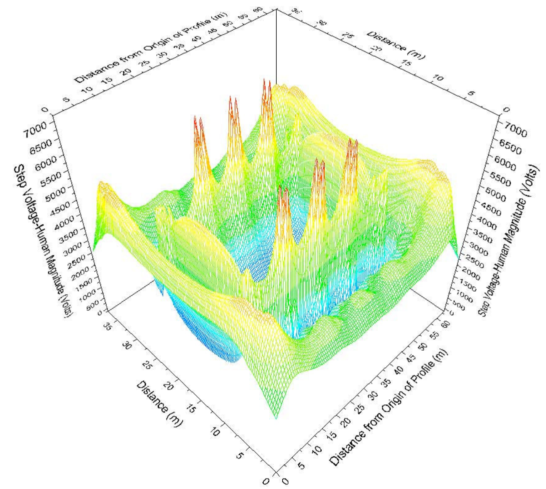
2.2. Large low structure

Similar calculations were made for the structure with the following dimensions 75 m x 51 m and height 6 m.

LPS with 2 ring earth electrodes



LPS with 3 ring earth electrodes



LPS with 4 ring earth electrodes

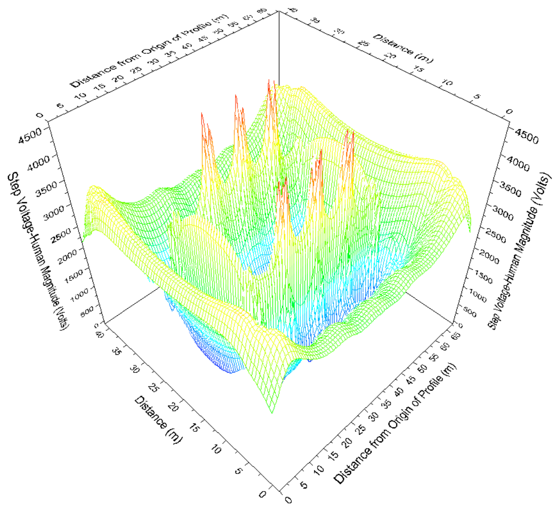


Fig. 7 - Step voltage distributions near building

The structure is protected by meshed air-termination nets with the mesh size 14,4 m x 16 m, 16 down conductors and ring earth electrode. In calculations additional ring electrodes, up to 4, were taken into account (Fig. 8.).

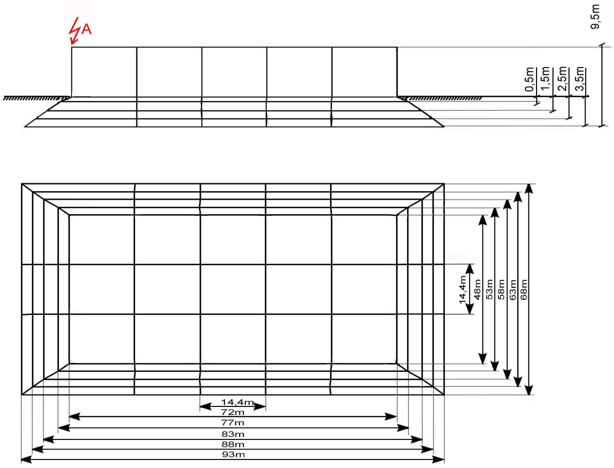


Fig. 8 - Geometrical configuration of shopping centre for the 1-4 rings earth electrode

Fig 9 and 10 show the step voltage distribution for the strike into corner of building's LPS with 1 and 4 ring earth electrodes.

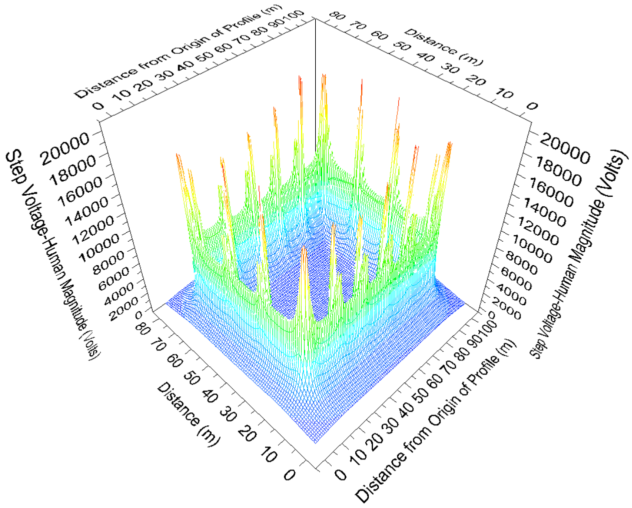


Fig. 9 - Step voltage distributions near building with (1 ring earth electrode)

3 CONCLUSION

Calculation showed, that that the values of step and touch voltages is strongly dependant on the grounding systems of LPS. Using additional rings it is possible several times reduced (up to 8 - 9 times in most complex grounding system for 4 rings) these voltages.
Modelling of objects creates possibility for selection of the grounding system for different kind of objects.

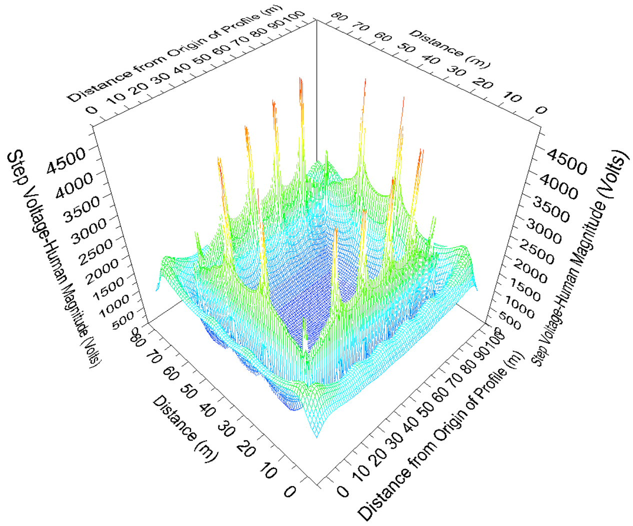


Fig. 10 - Step voltage distributions near building with (4 ring earth electrodes)

Acknowledgment

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4 REFERENCES

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[4] "HIFREQ User's Manual: Frequency Domain Analysis of Buried Conductor Networks" Safe Engineering Services & Technologies Ltd., Montreal Canada.

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[7] IEC 61312-1, International Standard, Protection against lightning electromagnetic