ELECTRIC SHOCK HAZARD ON THE MULTILAYER SIDEWALK DURING LIGHTNING STROKE

Jaroslaw Wiater
jaroslawwiater@vela.pb.bialystok.pl
Electrical Department, Białystok Technical University

Abstract: Sidewalk is a public place where thousands strollers can spend time. In this situation some questions appeared, which concerned the problems of electric shock hazard during lightning strokes and safe places for strollers during these thunderstorms. This paper tried to consider these problems.

1. INTRODUCTION

Different configurations of sidewalks are popular solution for the streets and squares and are the public places with thousands strollers.
In many cases sidewalk is made of the asphalt, paving brick, paving stone. These materials have got high resistivity in comparison with ground resistivity. Additionally during the storm sidewalk is wet. Water characterizes small resistivity in comparison with ground resistivity. It's thousand times lower. Very often in such situation sidewalk is not an isolated plate. There are always some gaps between paving stones and water flows into these gaps.
In this situation some questions appeared which concerned the problems of electric shock hazard during lightning strokes. Some guidelines for designers, safe places for strollers during thunderstorms will be proposed.

2. SIDEWALK ARRANGEMENT

Sidewalk is a part of the promenade. It often consists of additional elements such as fences, benches, flag poles, additional invisible buried construction such as pipes etc. Sidewalks are surrounded in many cases with trees. In this paper trees aren't taken into consideration. Flag pole can be some equivalent of the tree.
The arrangement which was analyzed is presented in Fig. 1. Sidewalk consists of 3 different layers. First one is 1 mm thick and represents water with resistivity 0.032 Ω·m. Second one is 100 mm thick and represents paving stones with resistivity 5000Ω·m. Third one have got infinity thickness and represents soil with standard resistivity 100 Ω·m. Flag pole is 15m high and have got simple grounding systems which consist of the three vertical rod placed 3m deep [1,2,3].

Numerical simulations were performed by MultiFields software package, which is a part of CDEGS package [4,5]. The numerical model includes an earthing network as well as simplified models of aboveground elements such as flag pole structure and bonding network.
The computation methodology assumes frequency decomposition of the time domain current surge [5], frequency domain computations for a single harmonic unit current energization and superposition of the frequency domain computations modulated by the amplitude of the lightning current – shape 10/350μs, peak value 200kA [4,5].

$$i(t) = \frac{I}{\eta}\left(e^{-\alpha t} - e^{-\beta t}\right) \qquad (1)$$

where:
t - time, a - reciprocal of time constant, b - reciprocal of time constant, I - peak current, η - correcting factor

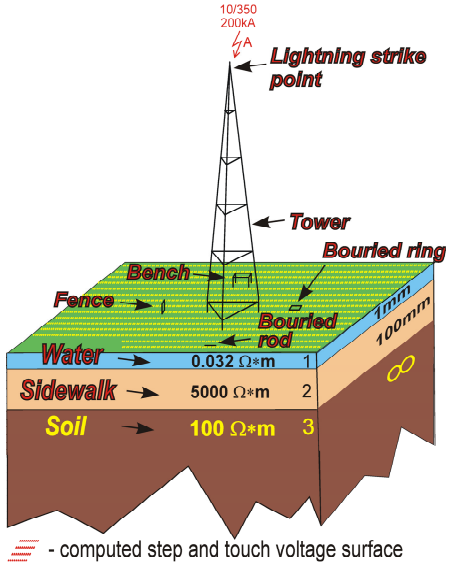

Fig. 1. Multilayer sidewalk

3. COMPUTATION RESULTS

Figure 2 presents a contour 3D plot of the step voltage distribution on the wet sidewalk surface. The maximal obtained values of lightning transient step voltage can reach 30kV around the vertical ground conductors, also that connecting the flag pole earthing terminals to the earthing system. About 10 times lower values – 3kV are observed in about 20m distances from the flagpole legs. Figure 3 presents a contour 3D plot of the reach touch voltage distribution.

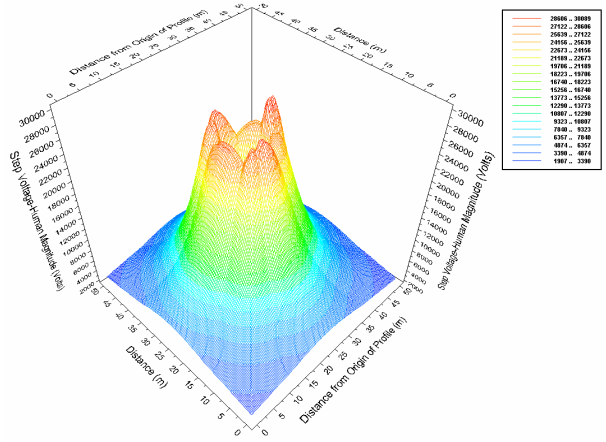

Fig. 2. Step voltage distribution of near the pole (t=10μs)

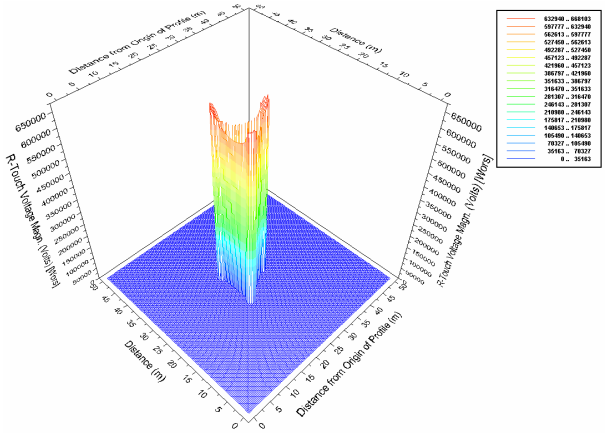

Fig. 3. Reach touch voltage distribution nearby the pole (t=10μs)

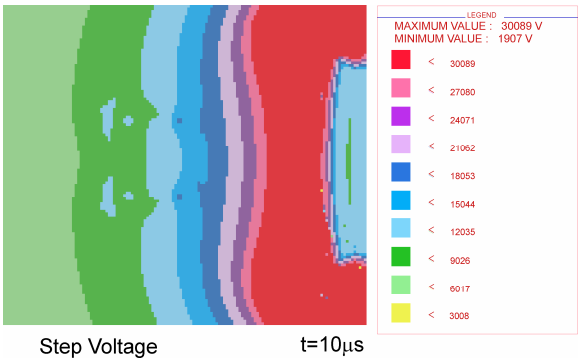

Fig. 4. Bench influence on the step voltage distribution

The maximal obtained value of touch voltage is in the 1m distance from flag pole and can reach 650kV. Figure 4 presents 2D view of the step voltage distribution nearby the flag pole.

Bench have got equipotential task on the sidewalk during lightning strike. Additionally bench averages scalar potential distribution nearby flag pole and by that minimize the locally step voltage level.

4. CONCLUSIONS

Fundamental conclusions from these calculations are simple. During the thunder storm stroller should walk away from sidewalk as fast as it's possible to the car or the building. If it's impossible to walk away stroller shouldn't touch any metallic elements for example fences. Safe distance from flag pole or any high structure during lightning is 50m.

If stroller haven't got any opportunity to walk away should sit on the bench and don't touch ground by the legs. It this position stroller will be on the high potential. On the sidewalk during the lightning strike step voltage is too high for human being. Designer should place as much as possible number of benches nearby by the promenade. During the sudden thunderstorm bench seems to be an only solution to secure strollers life.

5. ACKNOWLEDGMENT

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6. REFERENCES

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