World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:13, No:12, 2019

Strategies for the Optimization of Ground Resistance in Large Scale Foundations for Optimum Lightning Protection

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Abstract : In this paper, we discuss the standard improvements which can be made to reduce the earth resistance in difficult terrains for optimum lightning protection, what are the practical limitations, and how the modeling can be refined for accurate diagnostics and ground resistance minimization. Ground resistance minimization can be made via three different approaches: burying vertical electrodes connected in parallel, burying horizontal conductive plates or meshes, or modifying the own terrain, either by changing the entire terrain material in a large volume or by adding earth-enhancing compounds. The use of vertical electrodes connected in parallel pose several practical limitations. In order to prevent loss of effectiveness, it is necessary to keep a minimum distance between each electrode, which is typically around five times larger than the electrode length. Otherwise, the overlapping of the local equipotential lines around each electrode reduces the efficiency of the configuration. The addition of parallel electrodes reduces the resistance and facilitates the measurement, but the basic parallel resistor formula of circuit theory will always underestimate the final resistance. Numerical simulation of equipotential lines around the electrodes overcomes this limitation. The resistance of a single electrode will always be proportional to the soil resistivity. The electrodes are usually installed with a backfilling material of high conductivity, which increases the effective diameter. However, the improvement is marginal, since the electrode diameter counts in the estimation of the ground resistance via a logarithmic function. Substances that are used for efficient chemical treatment must be environmentally friendly and must feature stability, high hygroscopicity, low corrosivity, and high electrical conductivity. A number of earth enhancement materials are commercially available. Many are comprised of carbon-based materials or clays like bentonite. These materials can also be used as backfilling materials to reduce the resistance of an electrode. Chemical treatment of soil has environmental issues. Some products contain copper sulfate or other copper-based compounds, which may not be environmentally friendly. Carbon-based compounds are relatively inexpensive and they do have very low resistivities, but they also feature corrosion issues. Typically, the carbon can corrode and destroy a copper electrode in around five years. These compounds also have potential environmental concerns. Some earthing enhancement materials contain cement, which, after installation acquire properties that are very close to concrete. This prevents the earthing enhancement material from leaching into the soil. After analyzing different configurations, we conclude that a buried conductive ring with vertical electrodes connected periodically should be the optimum baseline solution for the grounding of a large size structure installed on a large resistivity terrain. In order to show this, a practical example is explained here where we simulate the ground resistance of a conductive ring buried in a terrain with a resistivity in the range of 1 kOhm·m.

Keywords : grounding improvements, large scale scientific instrument, lightning risk assessment, lightning standards
Conference Title : ICLE 2019 : International Conference on Lightning and Electrostatics
Conference Location : Tokyo, Japan
Conference Dates : December 04-05, 2019

Open Science Index, Environmental and Ecological Engineering Vol:13, No:12, 2019 publications.waset.org/abstracts/109485.pdf