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IMPACT OF DIFFERENT MATERIALS ELECTRODES IN EARTH GROUNDING SYSTEMS

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Abstract: *This paper presents results from experimental research work involving the improvement and also the different characteristics of grounding grids implemented with different materials. A comparison test is made between copper and steel grids in order to observe their performances. The results can be extended to other materials knowing their properties in regard with the two materials presented.*
Key words: *grounding, grounding electrodes, grounding electrode materials, cathodic protection, grounding grid.*

1. PROBLEM DESCRIPTION

The term earthing and grounding are used to refer to a conductor that is in close contact with the earth mass. It is usually implemented for safety reasons both residential and in industry. The general purpose is to provide safe passing for faulty currents. The grounding grid refers to all conducting elements connected together to form the safety grid including ground electrodes, connecting strip, connecting conductors and so on. In this paper a study of the materials used for ground electrodes in grounding grids is presented.

Usually earthing [1] is implemented anywhere electricity is used. It has the purpose to protect against faulty currents both the people and equipment. In order to meet some standards each grounding grid needs to have a resistance value specific to its purpose. In order to meet these values engineers take into consideration some factors like the number of ground electrodes, de length of the grounding system, soil resistivity and so on. In most cases when designing the safety grid all the above expressed factors are accounted but rather frequently the impact and the behavior of the grid over time is neglected. The parts that are under ground in this safety grid are the ones that are most exposed to corrosion. When corrosion appears the performance of the grounding system decreases.

2. APPLICATION FIELD

In Fig. 1 it is presented the concept of ground electrode buried in soil. It is part of the most common display of grounding grids. The conducting electrode is surrounded by soil of different properties. This electrode needs to be in good contact with the soil so it has no protection against corrosion. Another aspect to be consider is that almost in all cases this earthing grid is connected with all underground conducting structures [2].

By doing this the overall resistance of the grounding grid is reduced thus offering a better protection against hazardous currents [3]. Electrically interconnecting different conducting materials underground leads to a faster corrosion rate. This is not a problem for the metals that are close in the electromotive series such as cast iron, black iron or ductile iron. In this case only the corrosion done by the soil needs to be taken care of. The problem arises when interconnecting the above materials with copper and brass that are usually used as conductors [4]. This is due to the fact that copper, for example, is electro-positive to all ferrous metals used in construction. Two metals with different potentials in contact with each other if immersed in an electrolyte will result in a small current being generated and one of the metal will corrode [5].

3. RESEARCH STAGES

The simplest way is to use the same metals when implementing the grounding grid. This is not generally possible, so the solution is to use a cathodic protection system. A cathodic protection system is composed of a generator that produces a direct current which is supplied to the grid to be protected.

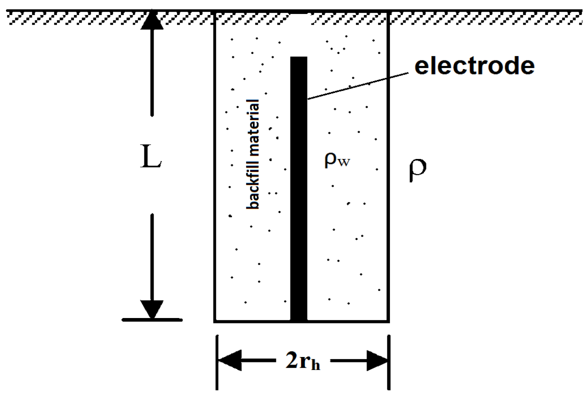

Fig. 1 Grounding electrode in soil

Table 1. Standard material potential

Materials	Stable	Potential (V)
Lithium	Li^{+}	-3,03
Potassium	K^{+}	-2,92
Calcium	Ca^{2+}	-2,87
Sodium	Na^{+}	-2,71
Magnesium	Mg^{2+}	-2,37
Aluminum	Al^{3+}	-1,66
Zinc	Zn^{2+}	-0,76
Iron	Fe^{3+}	-0,44
Lead	Pb^{2+}	-0,13
H_2	$2H^{+}$	0
Copper	Cu^{2+}	+0,34
Silver	Ag^{+}	+0,8
Mercury	Hg^{2+}	+0,85

When both metals are immersed in soil between them a flow of current will appear. From one metal the current will flow to the other one through soil and then will return through the conductor that binds them. The part were the corrosion will start is from the metal that the current leaves through the electrolyte and the metal that receives the current is cathodic protected.

Table 2. **Material resistivity**

Materials	Resistivity at 23^0C	Materials	Resistivity at 23^0C
Silver	$1,59 \times 10^{-8}$	Nichrom	$1,5 \times 10^{-6}$
Copper	$1,68 \times 10^{-8}$	Coal	$3,5 \times 10^{-5}$
Gold	$2,2 \times 10^{-8}$	Germanium	$4,6 \times 10^{-1}$
Aluminum	$2,65 \times 10^{-8}$	Silicon	$6,4 \times 10^{2}$
Tungsten	$5,6 \times 10^{-8}$	Human skin	5×10^{5}
Iron	$9,71 \times 10^{-8}$	Glass	10^{10}
Steel	$7,2 \times 10^{-7}$	Rubber	10^{13}
Platinum	$1,1 \times 10^{-7}$	Sulfur	10^{15}
Lead	$2,2 \times 10^{-7}$	Quartz	$7,5 \times 10^{17}$

As one can observe in the resistivity table, steel, which is usually connected with copper, has a much grater resistivity, resulting that in grounding grids made from copper the resistivity is 12 times lower than of those made from steel.

Table. 3. **Materials Permeability**

Material	Relative Permeability	Classification
Vacuum	0	Non-magnetic
Silver	0,99998	Diamagnetic
Aluminum	1,00002	Paramagnetic
Cobalt	250	Ferromagnetic
Nickle	600	Ferromagnetic
Iron	50000	Ferromagnetic

Another aspect to be considered is that the iron has 250 times the permeability of air.

A test was conducted to determine the properties of the materials used in grounding grids. Materials taken into consideration were iron and copper. Based on result the impact of other materials can be deduces taken into account their resistivity/conductivity values.

4. METHODS USED

In Figure 2 the impedance of the steel and copper materials was measured with respect to the soil resistivity.

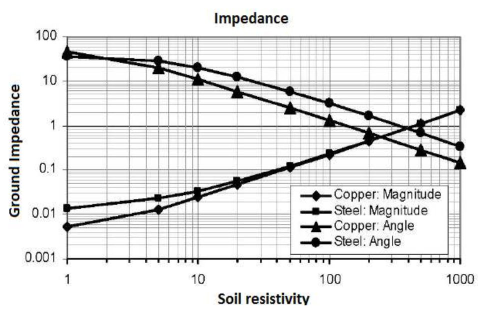

Fig. 2 Impedance of the soil

For a value of 3 ohms the impedance of the steel has a double value than that of copper and for a value of almost 600 ohms*m their impedances are almost the same. This proves that the higher the soil resistivity is the less difference of impedance between the two materials.

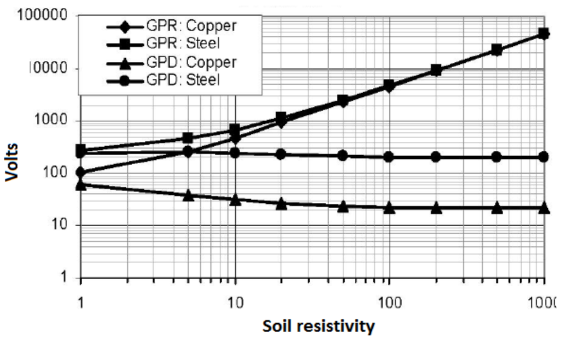

Fig. 3 Ground potential with respect to soil

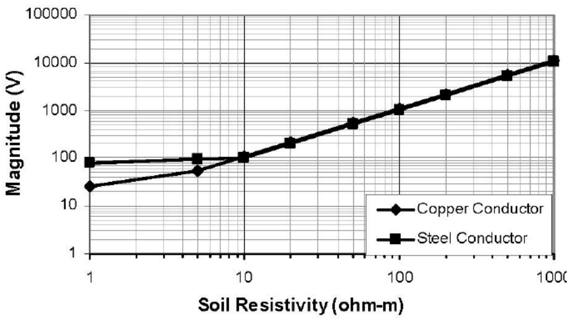

Fig. 4 Touch voltage

For the touch and step voltages, presented above, the results show that the lower the soil resistivity gets, the bigger the difference between the materials. That shows that the copper ground conductors are more effective.

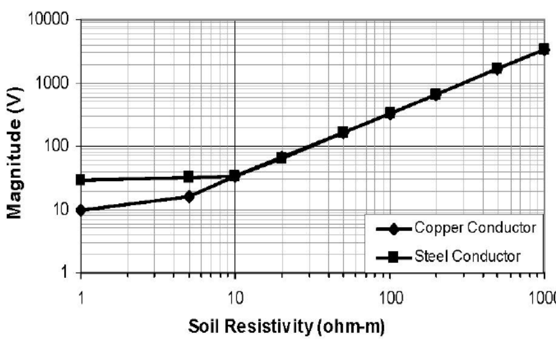

Fig. 5 Step voltage

As a conclusion so far, one can say that the differences between the two materials is greater as the soil resistivity is lower.

Below are the results for non-uniform soil:

Table 4. Results of non-uniform soil

Soil model		1	2	3	4
Impedance	Copper	0,5	0,1	0,8	0,06
	Steel	0,6	0,1	0,6	0,1
GPR (V)	Copper	11922	1981	12987	1314
	Steel	10427	2160	14412	2007
Touch voltage	Copper	711	1420	2023	275
	Steel	852	1799	2598	521
Step voltage	Copper	299	638	1009	119
	Steel	364	859	1242	219

5. RESULTS

A test to conduct the differences between the two materials based on the scale of the grounding grid was made.

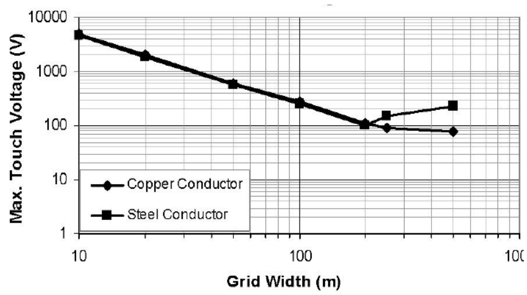

Fig. 6 Ground potential rise for non-uniform soil

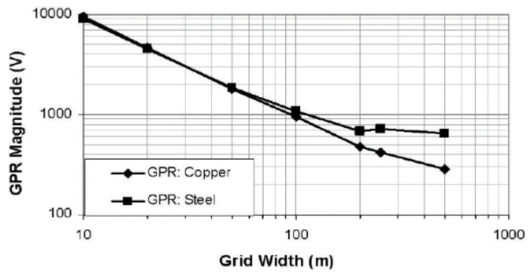

Fig. 7 Touch voltage for non-uniform soil

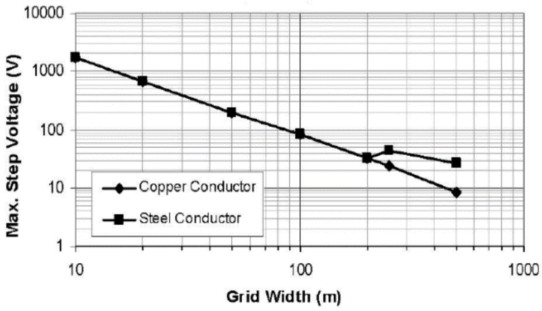

Fig. 8 Step voltage for non-uniform soil

Results show that the bigger the grid is the better the copper grounding is. For a grid of 600 x 600 meters the difference between the two systems is 149%.

6. CONCLUSIONS

The analysis of the performance of grounding systems made of steel or copper conductors has been carried out. The advantages of copper grounding grids over steel grids have been demonstrated. For uniform soils with high resistivity, grounding systems consisting of steel conductors have performance that is similar to those consisting of copper conductors. Due to the complexity of real soil structures, the performance of individual grounding systems must be evaluated correctly to avoid costly over-designs or dangerous under designs.

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Impactul diferitelor materiale folosite in electrozi asupra pămantarilor

Abstract. Lucrarea prezintă impactul diferitelor materiale folosite pentru realizarea electrozilor pămantarilor in implementarea acestora. Se propune compararea electrozilor realizati din cupru si otel pentru stabilirea caracteristicilor acestora. Rezultatele prezentate pot fi extrapolate si altor materiale cu conditia cunoasterii proprietatilor acestora.

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