Fluidized and Self Compacting Backfill with High Thermal Conductivity for Underground Insulated Cables Systems

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ABSTRACT

This article presents the development of a fluidized, low thermal resistivity, thermally stable and friable backfill. Low resistivity and thermal stability make possible to optimize cables, trenches and duct bank dimensions. The friability allows easier access for repairing the cables where they are eventually damaged.
The basic materials, the high thermal conductivity aggregates and the researched binders are mentioned.
The stages of the research and development project and the achieved results are shown.

KEYWORDS

Power Cable; Fluidized Backfill; Low Thermal Resistivity; Friable Backfill.

INTRODUCTION

The economic project of an underground electric line must necessarily consider:

- to use a conductor with a minimum section that allows the maximum nominal current to be transmitted;
- to use a backfill with low resistivity and good thermal stability and high mechanical strength to envelop the cables;
- to reduce the dimensions of the space occupied by the line.

The minimum section of the conductor depends directly on the apparent thermal resistivity of the set (soil / backfill), and the backfill thermal resistance accounts for about 60% of all thermal resistances involved in the conductor section calculation.

The use of thermally stabilized materials and low thermal resistivity as backfill in underground transmission lines is a long-standing practice. It ensures the employment of conductors of optimized cross section and lines with lower investment. The development of low resistivity and thermally stable fluidized backfill began in the eighties [1]. Afterwards, concretes with extremely high thermal conductivities were developed [2].

The best backfill available in Brazil today is composed of materials from volcanic rocks that provide thermal resistivity of 1 K.m / W, for dried material. For this backfill to be used as backfill material for buried cables, it is necessary that these rocks be properly milled with pre-specified granulometry and mixed with each other with specific water content and compacted in the trench surrounding the cables or ducts. This process, besides being time-consuming and dependent on rigid control during its execution, is at its lower thermal resistivity limit.

The dimensions of the trench depend on the depth and spacing between the cables and determine the cost of civil works in an objective manner. Among these costs, the backfill cost is of great importance because the amount of material involved, and the time required for its application represent a significant part of the total work.

Therefore, in order to have an economic project for an underground power line, it is necessary to optimize the conductors and the civil work that includes the materials that surround the cables (backfill).

The development of a backfill of lower thermal resistivity when dried and that can be applied in a mechanized way and without the necessity of conventional compaction through percussion compactors or vibratory plates. are the challenges that this research and development project, inserted in the R&D program of the Brazilian Regulatory Agency – ANEEL, has proposed to solve.

The physical characteristics of the new backfill material developed were determined at the beginning of the research in function of the needs of the concessionaire that funded the project. The following general characteristics have been defined:

- thermal resistivity equal to or less than 0.75 K.m / W
- thermally stabilized material;
- do not require compaction for application in the duct bank;
- flow in a similar way to concrete;
- provide stable subgrade for street pavement;
- mitigate problems of thermal instability of the soil;
- be applied with the help of concrete trucks;
- be used on flat or mountainous terrain;
- be pumped or spilled;
- be friable to allow the corrective maintenance of the cables.

STEPS OF THE R&D PROJECT

The research methodology applied in this project was composed of 4 interrelated phases:

1. selection of the basic solid materials, components of the new backfill, so that the backfill would meet the characteristics of high thermal conductivity, highlighting the following research activities:

- elaboration of an engineering specification for the physical and chemical characterization of the components materials of the new backfill;
- selection of materials;
- studies of changes in the surface characteristics of selected materials to improve their properties of thermal conductivity;
- laboratory evaluations to prove the best characteristics among the selected and modified materials versus the